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PROGRESS REPORT

BADGER WASH COOPERATIVE STUDY
PRECIPITATION, RUNOFF, AND SEDIMENT YIELD, 1969 SEASON

by

Gregg C. Lusby, Research Hydrologist

WATERSHED COVER AND FORAGE UTILIZATION 1969-1970

by

J. Robert Owen, Research Hydrologist

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U.S. Geological Survey

Progress Report

Badger Wash Cooperative Study

Precipitation, Runoff, and Sediment Yield, 1969 Season

by Gregg C. Lusby

Shown in the following tables are data on precipitation, runoff, and sediment yield obtained at the Badger Wash study area during 1969.

Precipitation amounts are shown in table 1. Average precipitation for the summer season as measured in 12 rain gages was 6.14 inches, which is 1.21 inches more than the average for the previous 15 years. Although the average precipitation was more than normal, storms were not large enough to produce appreciable runoff. More rain than normal occurred in June.

Runoff and sediment yield from all watersheds is shown in table 2 and runoff from paired watersheds is shown in table 3. Most of the sediment surveys showed compaction of reservoir sediments during the year.

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[When num ther records.]

Date		Watershed number							
		1	2	2A*	2B*	3A	3B	4A***	4B
Apr.	6	0.02	0.03	0.02	0.02	0.02	0.02	0.02	0.0
	14	.09	.09	.10	.11	.06	.07	.05	.0
	15	.11	.17	.31	.32	.12	.13	.27	.2
May	5	0	0	.02	.03	0	0	.02	.0
	6	.05	.09	.08	.07	.04	.04	.08	.0
	7	.23	.24	.21	.22	.21	.22	.19	.1
June	8	.02	(.01)	.01	.01	0	.01	.01	.01
	14	.03	.02	.04	.04	.02	.02	.05	.0
	15	.03	.05	.05	.02	.06	.07	.11	.12
	16	.06	.08	.05	.05	.05	.06	.07	.08
	17	.07	.11	.06	.04	.15	.16	.10	.11
	23	.68	.52	.53	.55	.65	.64	.52	.51
	24	.70	.69	.47	.45	.51	.51	.41	.40
	25	.07	.07	0	0	.05	.06	.06	.06
July	14	0	0	.02	.02	.02	.02	.03	.03
	19	.04	.06	.04	.04	.02	.02	.01	.01
	20	.18	.15	.19	.19	.18	.19	.16	.14
	29	.02	.01	.02	.02	.02	.02	0	0
	30	.06	.05	.03	.03	.03	.03	.01	.01
Aug.	10	0	.01	.01	.01	.02	.02	.04	.03
	11	0	0	0	0	.04	.03	0	0
	12	.21	.25	.18	.19	.21	.20	.09	.09
	16	.01	.01	.01	.01	.02	.02	.02	.02
	17	.02	.02	.02	.02	.02	.02	.02	.02
	23	.10	.17	.18	.22	.13	.16	.34	.34
	28	.24	.23	.23	.24	.23	.22	.15	.15
	29	.64	.64	.62	.63	.59	.60	.59	.59
Sept.	4	.04	.06	.05	.05	.05	.05	.03	.03
	10	0	.03	.05	.05	0	.01	.03	.04
	13	.08	.06	.09	.10	.05	.06	.07	.07
	14	.03	.04	.03	0	.02	.01	.05	.05
	15	0	0	.02	.02	0	0	0	0
	16	0	0	.02	.02	0	0	0	0
	21	.40	.49	.52	.44	.45	.47	.60	.60
	22	0	0	.01	.01	0	0	.02	.02
	27	0	0	.01	.01	0	0	0.02	0.02

Table 1.--Precipitation, Badger Wash (April 1 to November 6, 1969)

[When numbers are shown in parentheses, no daily record obtained. Amounts estimated from total catch or other records.]

Date		Amount (inches)																			
		Gage number												Watershed number							
		1	2	3	3A	4	5	6	7	7A	8	9	11	1A	1B	2A*	2B*	3A	3B	4A***	4B**
Apr.	6	0.02	0.03	0.02	0.02	(0.03)	0.02	0.03	(0.03)	0.02	(.02)	.02	(0.02)	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
	14	.09	.09	.08	.11	(.08)	.06	.08	.03	.06	(.05)	.02	(.03)	.09	.09	.10	.11	.06	.07	.05	.06
	15	.11	.17	.24	.32	.30	.12	.17	.22	.26	.30	.24	.50	.11	.14	.31	.32	.12	.13	.27	.28
May	5	0	0	0	.03	0	0	0	.02	.03	(.02)	0	0	0	0	.02	.03	0	0	.02	.03
	6	.05	.09	.05	.07	.10	.04	.05	.05	.09	.10	.04	.10	.05	.07	.08	.07	.04	.04	.08	.09
	7	.23	.24	.18	.22	.20	.21	.24	.19	.18	.20	.20	.30	.23	.23	.21	.22	.21	.22	.19	.19
June	8	.02	(.01)	(.01)	.01	(.01)	0	.02	(.01)	.01	0	0	0	.02	.02	.01	.01	0	.01	.01	.01
	14	.03	.02	.03	.04	(.03)	.02	.02	(.03)	.05	(.05)	.04	.10	.03	.03	.04	.04	.02	.02	.05	.05
	15	.03	.05	.01	.02	.10	.06	.08	(.10)	.13	.10	.08	(.05)	.03	.04	.05	.02	.06	.07	.11	.12
	16	.06	.08	.04	.05	(.05)	.05	.08	(.05)	.06	.10	.07	.10	.06	.07	.05	.05	.05	.06	.07	.08
	17	.07	.11	.09	.04	.10	.15	.20	(.11)	.11	.10	.07	.10	.07	.09	.06	.04	.15	.16	.10	.11
	23	.68	.52	.61	.55	.50	.65	.63	(.50)	.52	.50	.52	.70	.68	.60	.53	.55	.65	.64	.52	.51
	24	.70	.69	(.40)	.45	.50	.51	.50	(.38)	.40	.40	.44	.40	.70	.70	.47	.45	.51	.51	.41	.40
	25	.07	.07	(0)	0	0	.05	.08	(.05)	.04	.10	.05	(.05)	.07	.07	0	0	.05	.06	.06	.06
July	14	0	0	.02	.02	(.03)	.02	.03	(.03)	.03	(.03)	.02	(.02)	0	0	.02	.02	.02	.02	.03	.03
	19	.04	.06	.05	.04	(.04)	.02	.01	(.01)	.01	(.02)	.01	(.02)	.04	.05	.04	.04	.02	.02	.01	.01
	20	.18	.15	.19	.19	.20	.18	.22	(.16)	.17	.10	.18	.10	.18	.17	.19	.19	.18	.19	.16	.14
	29	.02	.01	.01	.02	(.02)	.02	.03	0	0	0	0	0	.02	.02	.02	.02	.02	.02	0	0
	30	.06	.05	.02	.03	(.03)	.03	.04	0	.01	0	0	0	.06	.06	.03	.03	.03	.03	.01	.01
Aug.	10	0	.01	.01	.01	(.01)	.02	.01	(.02)	.03	(.04)	.05	0	0	0	.01	.01	.02	.02	.04	.03
	11	0	0	0	0	0	.04	.02	0	0	(0)	.01	(0)	0	0	0	0	.04	.03	0	0
	12	.21	.25	.19	.19	.15	.21	.17	.07	.09	.10	.09	.10	.21	.23	.18	.19	.21	.20	.09	.09
	16	.01	.01	.01	.01	(.01)	.02	.01	.01	.02	(.02)	.02	(.02)	.01	.01	.01	.01	.02	.02	.02	.02
	17	.02	.02	.02	.02	(.02)	.02	.01	.02	.02	(.02)	.01	(.02)	.02	.02	.02	.02	.02	.02	.02	.02
	23	.10	.17	.41	.22	(.08)	.13	.26	.33	.36	.03	(.30)	(.08)	.10	.13	.18	.22	.13	.16	.34	.34
	28	.24	.23	.28	.24	.20	.23	.21	.16	.19	.10	(.10)	.10	.24	.24	.23	.24	.23	.22	.15	.15
	29	.64	.64	.59	.63	.60	.59	.61	.58	.58	.60	(.60)	.60	.64	.64	.62	.63	.59	.60	.59	.59
Sept.	4	.04	.06	.03	.05	(.05)	.05	.05	.02	.03	(.03)	(.02)	(.02)	.04	.05	.05	.05	.05	.05	.03	.03
	10	0	.03	.02	.05	(.05)	0	.03	.03	.04	(.03)	0	0	0	.01	.05	.05	0	.01	.03	.04
	13	.08	.06	.09	.10	(.06)	.05	.07	.06	.07	(.07)	(.08)	.20	.08	.07	.09	.10	.05	.06	.07	.07
	14	.03	.04	0	0	.10	.02	0	0	.01	.10	(.01)	0	.03	.03	.03	0	.02	.01	.05	.05
	15	0	0	.01	.02	(.01)	0	0	0	0	0	0	0	0	0	.02	.02	0	0	0	0
	16	0	0	.01	.02	(.02)	0	0	0	0	0	0	0	0	0	.02	.02	0	0	0	0
	21	.40	.49	.45	.44	.70	.45	.53	.53	.60	.60	(.60)	.60	.40	.44	.52	.44	.45	.47	.60	.60
	22	0	0	.01	.01	0	0	.01	.01	.02	(.02)	.03	(.05)	0	0	.01	.01	0	0	.02	.02
	27	0	0	(.01)	.01	0	0	0	0	0	0	0	0	0	0	.01	.01	0	0	0.[illegible]	0.[illegible]

[When numbe her records.]

Date	Watershed number							
	1	2	2A*	2B*	3A	3B	4A**	4B
Oct. 2	.09	.08	.08	.09	.10	.10	.10	.
3	.05	.05	.07	.05	.05	.04	.06	.(
44	.02	.05	.07	.05	.08	.09	.19	.
10	.39	.47	.35	.37	.37	.38	.35	.
11	.01	.02	.05	.02	.05	.04	.02	.(
14	.12	.12	.11	.12	.11	.11	.10	.1
16	.22	.27	.21	.22	.24	.24	.24	.2
17	.10	.11	.10	.10	.08	.08	.07	.0
18	.18	.12	.17	.15	.14	.14	.19	.1
22	.39	.39	.39	.38	.38	.39	.39	.3
23	.01	.01	.02	.02	0	0	.01	.0
28	.14	.18	.23	.20	.19	.20	.28	.2
Total Apr. 1-Nov.6,1969	5.95	6.32	6.15	6.02	5.83	5.95	6.22	6.2(
Nov. 11, 1968-Nov. 6, 1969	11.39	11.75	--	--	--	--	--	--

* Gage 3A used in computations f

** Gage 7A used in computations f

Table 1.--Precipitation, Badger Wash (April 1 to November 6, 1969)--Cont.

[When numbers are shownin parentheses, no daily record obtained. Amounts estimated from total catch or other records.]

Date	Amount (inches)																			
	Gage number												Watershed number							
	1	2	3	3A	4	5	6	7	7A	8	9	11	1A	1B	2A*	2B*	3A	3B	4A**	4B**
Oct. 2	.09	.08	(.08)	.09	(.07)	.10	.11	.05	.10	.10	.08	(.08)	.09	.09	.08	.09	.10	.10	.10	.10
3	.05	.05	(.05)	.05	.10	.05	.03	.06	.05	(.05)	.08	.10	.05	.05	.07	.05	.05	.04	.06	.05
44	.02	.05	(.05)	.05	.10	.08	.13	.17	.18	.20	.19	.20	.02	.03	.07	.05	.08	.09	.19	.19
10	.39	.47	(.35)	.37	.30	.37	.39	.33	(.33)	.40	.37	.50	.39	.43	.35	.37	.37	.38	.35	.36
11	.01	.02	(.02)	.02	.10	.05	.02	.03	(.02)	(.04)	.02	(.03)	.01	.01	.05	.02	.05	.04	.02	.03
14	.12	.12	.10	.12	.10	.11	.12	.10	.10	.10	.09	.10	.12	.12	.11	.12	.11	.11	.10	.10
16	.22	.27	.20	.22	.20	.24	.25	.22	.25	.20	.28	.20	.22	.24	.21	.22	.24	.24	.24	.23
17	.10	.11	.07	.10	.10	.08	.08	.08	.07	.10	.06	.10	.10	.10	.10	.10	.08	.08	.07	.08
18	.18	.12	.13	.15	.20	.14	.15	.22	.19	.20	.19	.20	.18	.15	.17	.15	.14	.14	.19	.19
22	.39	.39	.38	.38	.40	.38	.43	.36	.39	.40	.39	.40	.39	.39	.39	.38	.38	.39	.39	.39
23	.01	.01	.02	.02	(.02)	0	0	.05	.01	(.01)	.01	(.01)	.01	.01	.02	.02	0	0	.01	.01
28	.14	.18	.20	.20	.30	.19	.21	.29	.27	.30	.31	.30	.14	.16	.23	.20	.19	.20	.28	.28
Total Apr. 1-Nov.6,1969	5.95	6.32	5.84	6.02	6.37	5.83	6.42	5.77	6.20	6.32	5.99	6.60	5.95	6.12	6.15	6.02	5.83	5.95	6.22	6.26
Nov. 11, 1968- Nov. 6, 1969	11.39	11.75	11.08	--	--	10.87	11.78	10.24	--	--	10.78	--	--	--	--	--	--	--	--	--

* Gage 3A used in computations for watersheds 2A and 2B.
** Gage 7A used in computations for watersheds 4A and 4B.

Table 2.--Runoff at Badger Wash, 1969

Drainage basin	Drainage area (sq mi)	Runoff		Sediment	
		Acre-ft	Acre-ft per sq mile	Acre-ft	Acre-ft per sq mile
1A	0.066	0	0	0	0
1B	.084	0	0	0	0
2A	.148[1]	0	0	0	0
2B	.158	0	0	0	0
3A	.059	.11	1.86	.02	.34
3B	.048	.01	.21	T	0
4A	.022	0	0	0	0
4B	.019	0	0	0	0
5	.055	.27	4.91	T	T
6	.220	.45	2.05	T	T
7	.094	0	0	0	0
8	.109	.02	.18	T	T
9	.313	.90	2.88	T	T
10	.100	.32	3.20	T	T
11	.089	.36	4.04	T	T
12	.092	.63	6.85	T[3]	T
13	.484	0	0	0	0
14	1.53	2.18	1.42	.02	.01
15	.136[2]	.11	.81	T	T
16	.239[2]	.02	.08	T	T

[1] Excluding runoff from auxiliary watershed.

[2] Drainage area approximate. To be computed at a later date.

[3] Deposition in 1968, 0.25 acre-feet, 2.72 acre-feet per sq mile.

T Amount too small to measure.

Table 3.--Runoff, Badger Wash
Observation Reservoir 1A

ocation.--Lat 39°20', long 108°56', in sec. 24, T. 8 S., R. 104 W., near Mack, Mesa Co., Colo.

rainage area.--0.066 sq mi (42 acres).

ecords available.--April 1954 to November 1969, summer months only.

age.--Water-stage recorder. Elevation of gage 5,058.08 ft above mean sea level.

unoff and discharge determination.--Contents of reservoir and volume of inflow computed from a stage-capacity curve of the reservoir.

axima.--Maximum storm inflow 3.27 acre-ft, 49.5 acre-ft per sq mile, July 25, 1955.

emarks.--Records good.

apacities.--At spillway level (gage-ht of 54.7 ft):
December 1953 - 8.10 acre ft
July 1955, November 1956 - 7.39 acre-ft
October 1957, November 1958 - 7.15 acre-ft
November 1959 - 6.86 acre-ft
November 1961 - 6.50 acre-ft
November 1962 - 6.42 acre-ft
November 1963 - 6.37 acre-ft
November 1964 - 6.33 acre-ft
November 1965 - 5.88 acre-ft
November 1966 - 5.88 acre-ft
November 1967 - 5.72 acre-ft
November 1968 - 5.20 acre-ft
November 1969 - 5.26 acre-ft

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Watershed 1A, Storm runoff, April 1 to November 6, 1969

No runoff.

Table 3.--Runoff, Badger Wash--Continued
Observation Reservoir 1B

Location.--Lat 39°20', long 108°56', in sec. 25, T. 8 S., R. 104 W., near Mack, Mesa Co., Colo.

Drainage area.--0.084 sq mi (54 acres).

Records available.--April 1954 to November 1969, summer months only.

Gage.--Water-stage recorder. Elevation of gage is 5,023.92 ft above mean sea level.

Runoff and discharge determinations.--Contents of reservoir and volume of inflow computed from a stage-capacity curve of the reservoir.

Maxima.--Maximum storm inflow volume 3.46 acre-ft, 41.2 acre-ft per sq mile, July 26, 1968.

Remarks.--Records good.

apacities.--At spillway level (gage-ht of 19.5 ft):
December 1953 - 19.8 acre-ft
July 1955, November 1956 - 19.2 acre-ft
October 1957, November 1958, November 1959 - 19.1 acre-ft
November 1961 - 18.7 acre-ft
November 1962 - 18.6 acre-ft
November 1963 - 18.5 acre-ft
November 1964 - 18.5 acre-ft
November 1965 - 18.2 acre-ft
November 1966 - 18.2 acre-ft
November 1967 - 18.0 acre-ft
November 1968 - 17.4 acre-ft
November 1969 - 17.4 acre-ft

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Watershed 1B, storm runoff, April 1 to November 6, 1969

No runoff.

Table 3.--Runoff, Badger Wash--Continued
Observation Reservoir 2A

Location.--Lat 39°20', long 108°57', in sec. 36, T. 8 S., R. 104 W., near Mack, Mesa Co., Colo.

Drainage area.--0.148 sq mi (95 acres).

Records available.--April 1954 to November 1969, summer months only.

Gage.--Water-stage recorder. Elevation of gage is 4,946,43 ft above mean sea level. Reservoir of side drainage in same watershed equipped with reference mark, crest stages noted. Elevation of reference mark is 4,940 ft (from topographic map).

Runoff and discharge determinations.--Contents of reservoirs and volume of inflow computed from a stage capacity curve of the reservoir.

Maxima.--Maximum storm inflow volume 7.71 acre-ft, 46.2 acre-ft per sq mile, July 25, 1955. Inflow lasted 50 minutes.

Remarks.--Records good.

Capacities.--At spillway level.

Main reservoir

Dec. 1953 - 6.34 acre-ft
July 1955, Nov. 1956 - 4.42 acre-ft
Oct. 1957, Nov. 1958 - 3.93 acre-ft
ov. 1959 - 3.72 acre-ft
am raised Nov. 1959
ov. 1959 - 15.08 acre-ft
ov. 1961 - 13.86 acre-ft
ov. 1962 - 13.70 acre-ft
ov. 1963 - 13.53 acre-ft
ov. 1964 - 12.40 acre-ft
ov. 1965 - 12.07 acre-ft
ov. 1966 - 12.07 acre-ft
ov. 1967 - 11.49 acre-ft
ov. 1968 - 10.52 acre-ft
v. 1969 - 10.60 acre-ft

Auxiliary reservoir

Dec. 1953 - 6.14 acre-ft
July 1955, Nov. 1956, Oct. 1957, Nov. 1958 - 5.71 acre-ft
Nov. 1959 - 5.61 acre-ft
July 1962 - 5.55 acre-ft
Nov. 1963 - 5.49 acre-ft
Nov. 1964 - 5.31 acre-ft
Nov. 1965 - 5.18 acre-ft
Nov. 1966 - 5.18 acre-ft
Nov. 1967 - 5.24 acre-ft
Nov. 1968 - 4.98 acre-ft
Nov. 1969 - 5.00 acre-ft

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Watershed 2A, Storm runoff, April 1 to November 6, 1969

No runoff.

Table 3.--Runoff, Badger Wash--Continued
Observation Reservoir 2B

ocation.--Lat 39°20', long 108°57', in sec. 25, T. 8 S., R. 104 W., near Mack, Mesa Co., Colo.

rainage area.--0.158 sq mi (101 acres).

ecords available.--April 1954 to November 1969, summer months only.

ge.--Water-stage recorder. Elevation of gage is 4,970 ft above mean sea level.

noff and discharge determinations.--Contents of reservoir and volume of inflow computed from a stage capacity curve of the reservoir.

xima.--Maximum storm inflow volume 6.29 acre-ft, 39.8 acre-ft per sq mile, July 25, 1955. Inflow lasted 90 minutes.

marks.--Records good.

pacities.--At spillway level.
December 1953 - 8.45 acre-ft
July 1955, November 1956, October 1957, November 1958 - 6.05 acre-ft
Dam raised
June 1959 - 24.8 acre-ft
November 1959 - 24.5 acre-ft
November 1961 - 23.8 acre-ft
November 1962 - 23.6 acre-ft
November 1963 - 23.5 acre-ft
November 1964 - 23.0 acre-ft
November 1965 - 22.7 acre-ft
November 1966 - 22.7 acre-ft
November 1967 - 22.3 acre-ft
November 1968 - 21.3 acre-ft
November 1969 - 21.5 acre-ft

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Watershed 2B, Storm runoff, April 1 to November 6, 1969

No runoff.

Table 3.--Runoff, Badger Wash--Continued
Observation Reservoir 3A

ocation.--Lat 39°20', long 108°56', in sec. 25, T. 8 S., R. 104 W., near Mack, Mesa Co., Colo.

rainage area.--0.059 sq mi (38 acres).

ecords available.--April 1954 to November 1969, summer months only.

age.--Water-stage recorder. Elevation of gage 5,033.68 ft above mean sea level.

unoff and discharge computations.--Contents of reservoir and volume of inflow computed from a stage capacity curve of the reservoir.

axima.--Maximum storm inflow volume 2.98 acre-ft, 50.5 acre-ft per sq mile, July 25, 1955.

emarks.--Records good.

apacities.--At spillway level.
December 1956 - 12.90 acre-ft
July 1955, November 1956 - 12.63 acre-ft
October 1957, November 1958 - 12.53 acre-ft
November 1959 - 12.32 acre-ft
November 1961 - 12.12 acre-ft
November 1962 - 12.03 acre-ft
November 1963 - 12.00 acre-ft
November 1964 - 11.97 acre-ft
November 1965 - 11.53 acre-ft
November 1966 - 11.53 acre-ft
November 1967 - 11.33 acre-ft
November 1968 - 10.86 acre-ft
November 1969 - 10.84 acre-ft

Table on next page.

Watershed 3A, Storm runoff, April 1 to November 6, 1969

	Precipitation (inches)	Inflow		
		Acre-ft	Acre-ft per sq mile	Inches
June 23	0.65	0.10	1.69	0.032
Oct. 28	.19	.01	.17	.003
Total	--	0.11	1.86	.035

Table 3.--Runoff, Badger Wash--Continued
Observation Reservoir 3B

ocation.--Lat 39°20', long 108°56', in sec. 25, T. 8 S., R. 104 W., near Mack, Mesa Co., Colo.

rainage area.--0.048 sq mi (31 acres).

ecords available.--April 1954 to November 1969, summer months only.

age.--Water-stage recorder. Elevation of gage is 5,013.80 ft above mean sea level.

unoff and discharge determinations.--Contents of reservoir and volume of inflow computed from a stage capacity curve of the reservoir.

axima.--Maximum storm runoff volume 2.35 acre-ft, 49.6 acre-ft per sq mile, July 25, 1955.

emarks.--Records good.

apacities.--At spillway level.
December 1953 - 8.10 acre-ft
July 1955, November 1956 - 7.69 acre-ft
October 1957, November 1958 - 7.65 acre-ft
November 1959 - 7.52 acre-ft
November 1961 - 7.38 acre-ft
November 1962 - 7.16 acre-ft
November 1963 - 6.99 acre-ft
November 1964 - 6.97 acre-ft
November 1965 - 6.74 acre-ft
November 1966 - 6.74 acre-ft
November 1967 - 6.47 acre-ft
November 1968 - 6.00 acre-ft
November 1969 - 6.11 acre-ft

Table on next page.

Watershed 3B, Storm runoff, April 1 to November 6, 1969

Date	Precipitation (inches)	Inflow		
		Acre-ft	Acre-ft per sq mile	Inches
Oct. 28	0.20	0.01	0.21	0.004
Total	--	.01	.21	.004

Table 3.--Runoff, Badger Wash--Continued

Observation Reservoir 4A

Location.--Lat 39°19', long 108°56', sec. 36, T. 8 S., R. 104 W., near Mack, Mesa Co., Colo.

Drainage area.--0.022 sq mi (14 acres).

Records available.--April 1954 to November 1969, summer months only.

Gage.--Water-stage recorder. Elevation of reference mark is 4,944.83 ft above mean sea level.

Runoff and discharge determinations.--Contents of reservoir and volume of inflow computed from a stage-capacity curve of the reservoir.

Maxima.--Maximum storm inflow volume, 1.20 acre-ft, 54.5 acre-ft per sq mi, July 25, 1955. Inflow lasted 45 minutes.

Remarks.--Records good.

Capacities.--At spillway level.
December 1953 - 3.05 acre-ft
July 1955, November 1956 - 2.60 acre-ft
October 1957, November 1958 - 2.39 acre-ft
November 1959 - 2.33 acre-ft
November 1961, November 1962 - 2.10 acre-ft
November 1963 - 2.05 acre-ft
November 1964 - 1.90 acre-ft
November 1965 - 1.72 acre-ft
November 1966 - 1.72 acre-ft
November 1967 - 1.61 acre-ft
November 1968 - 1.47 acre-ft
November 1969 - 1.47 acre-ft

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Watershed 4A, Storm runoff, April 1 to November 6, 1969

No runoff.

Table 3.--Runoff, Badger Wash--Continued
Observation Reservoir 4B

Location.--Lat 39°19', long 108°56', in sec. 36, T. 8 S., R. 104 W., near Mack, Mesa Co., Colo.

Drainage area.--0.019 sq mi (12 acres).

Records available.--April 1954 to November 1969, summer months only.

Gage.--Water-stage recorder. Elevation of reference mark is 4,969.96 ft above mean sea level.

Runoff and discharge determinations.--Contents of reservoir and volume of inflow computed from a stage-capacity curve of the reservoir.

Maxima.--Maximum inflow 48.0 cfs, 5:45 pm, July 25, 1955. Maximum storm inflow volume 0.77 acre-ft, 40.5 acre-ft per sq mi, July 25, 1955

Remarks.--Records good.

Capacities.--At spillway level.
December 1953 - 4.52 acre-ft
July 1955, November 1956 - 4.24 acre-ft
October 1957, November 1958 - 4.16 acre-ft
November 1959, November 1961 - 4.11 acre-ft
November 1962 - 4.09 acre-ft
November 1963 - 4.05 acre-ft
November 1964 - 3.98 acre-ft
November 1965 - 3.85 acre-ft
November 1966 - 3.85 acre-ft
November 1967 - 3.77 acre-ft
November 1968 - 3.70 acre-ft
November 1969 - 3.78 acre-ft

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Watershed 4B, Storm runoff, April 1 to November 6, 1969

No runoff.

Badger Wash Progress Report 1969-1970

Watershed cover, forage utilization, and soil moisture

by J. Robert Owen

Watershed cover - Spring 1969

Watershed cover was sampled on the eight experimental watersheds in late March and early April 1969 using the all contacts point quadrat method. These data are summarized in Table 1. An estimate of watershed cover is obtained by projecting pins, spaced two inches apart in a rigid frame, vertically downward along a fifty foot transect. All contacts with bare soil, rock (particles >2mm in diameter), mulch or living stems and leaves are considered hits. Contacts are recorded as hits per 100 pins and generally exceed 100. Live vegetation is recorded by species.

Compared to the fall 1968 records bare soil decreased an average of four hits per 100 pins while mulch increased four hits per 100 pins on the watersheds that have been protected from grazing since 1953. Hits on vegetation increased an average of three hits per 100 pins. West Twin and Prairie Dog watersheds which have been protected from livestock since 1966 had an average decrease in bare soil of six hits per 100 pins while mulch increased by five hits.

Upper Hanks watershed, moderately grazed in December 1968, had an increase in bare soil of three hits per 100 pins, an increase in mulch of three hits, and a decrease of ten hits on live vegetation. Oilwell watershed, lightly grazed in 1968, decreased in bare soil and increased in mulch.

Forage Utilization:

Sheep grazed the experimental watersheds at two different periods during the 1970 winter grazing season. The use was as follows:

Date	No. Animals	Sheep Days
Jan. 12-15	1580	6320
Feb. 18-21	1565	6260
Feb. 19-21	285	855
Total sheep days		13,435

While this was a moderately heavy stocking rate, forage utilization was surprisingly light. The animals concentrated in Upper Hanks watershed, the same as during the 1969 grazing season. This was evident from the utilization estimates, and by the degree of trampling. There was a large increase in percent of bare soil, as recorded by the loop method, accompanied by a decrease in rock and litter over the September 1969 record. Oilwell, on the other hand, had very little trampling, and the percentages of bare soil, rock, and litter were about the same as the September record (Table 2).

Use of galleta grass was 17 percent on Upper Hanks watershed and only 2 percent on Oilwell. This is compared to the long term average use of galleta grass of 37 percent. Use of salina wildrye, green's rabbitbrush, and big sagebrush approximated past use on Upper Hanks, but was exceptionally light on Oilwell. Salina wildrye was grazed only 33 percent compared to the long term average of 71 percent. Shadscale and nuttall saltbush were lightly grazed in both watersheds. Utilization estimates and frequency of occurrance by species and by watershed are summarized in Table 3.

Since the livestock operation changed from a winter-spring sheep operation to winter sheep operation in 1966, use of grasses has generally decreased, while the use of shrubs has remained about the same. Utilization of important grasses and shrubs on Upper Hanks and Oilwell watersheds for both grazing periods are compared in Table 4.

Plant-soil relationships:

Soil is the controlling factor in the plant distribution at Badger Wash. Sandstone lenses underlie much of the watersheds on the western and northern parts of the basin. Soil that has developed from this material supports mainly shadscale with an understory of galleta grass. Big sagebrush, salina wildrye, snakeweed, and green's rabbitbrush contribute to the floristic composition of this community. Saturation percentage and soluble salt content is relatively low on these sites.

Nuttall saltbush dominates the soils that have considerably more soluble salts. These soils are derived from shale and generally are finer textured than the soils supporting shadscale.

Galleta grass is found on the coarser textured nuttall saltbush sites, but as the saturation percent increases it becomes less common. Green's rabbitbrush, phlox, and Eriogonum bicolor become more common as saturation percent and soluble salt content increase.

Sagebrush is found within the shadscale community on sites with a moderate saturation percent and low soluable salts. Snakeweed, spiny horsebrush, and salina wildrye occur within both shadscale and nuttall saltbush communities. Mat saltbush is found only on the finext textured, saltiest soils.

Soil Moisture:

Soils were sampled at each vegetation cluster (12 per watershed, 96 total) with a two-inch auger in the fall of 1967 and again in April 1968. The fall samples were analyzed for end of the growing season moisture content and total soil moisture stress in the 1-3, 2-2, 2-3, and 3-1 horizons. These designations represent the surface soil horizon, zone of maximum root concentration, zone of diminishing roots, and zone of occasional roots respectively. Spring samples were analyzed for moisture content and total soil moisture stress at the beginning of the growing season. In addition determinations were made for bulk density, saturation moisture content. These data are summarized for the two plant communities in Table 5.

Soil and soil moisture data collected at Badger Wash at the end of the growing season in 1967 revealed no significant differences in the soil moisture content or soil moisture stress between the grazed and non-grazed treatments.

There were no significant differences in the fall soil moisture content between nuttall saltbush and shadscale communities. Soil moisture stress, however, was significantly higher in the 1-3, 2-2, and 2-3 horizons of the nuttall saltbush community (Table 5). The finer textured soils of this community have a greater water holding capacity than coarser soils of the shadscale community, however, the water is held more tightly against removal by plants or evaporation.

Precipitation during the 1967-1968 winter period was above average (5.04 inches). In addition over 1.5 inches of rain and snow fell in April before the spring soil moisture sampling program. Soil moisture stress data reveal that the soil was wetter than field capacity (approximately 0.23 bars) to a depth of 27.5 inches under the shadscale community and to a depth of 16.1 inches under the nuttall saltbush community.

Soil moisture recharge for the profile may be computed from the difference between fall and spring soil moisture content. Average recharge for the shadscale community was 3.22 inches per profile, while only 2.14 inches was recharged under the nuttall saltbush community.

Table 1.--Watershed cover summary--All Contacts

March-April 1969

Watershed	Hits/100 pins			
	Bare Soil	Rock	Mulch	Live Vegetation
Upper Hanks	56	15	34	22
Lower Hanks	59	13	31	26
West Twin	60	12	34	32
Yucca	45	23	37	26
Oilwell	70	8	22	17
North Basin	70	6	27	22
Prairie Dog	50	35	17	21
Windy Point	53	28	20	23

Table 2.--Seasonal changes in ground cover on grazed and non-grazed watersheds.

Loop Method

	Date	Upper Hanks	Lower Hanks	Oilwell	North Basin
Bare Soil*	8/68	42	51	67	71
	4/69	48	55	69	72
	9/69	47	55	72	75
	2/70	63	56	70	71
Rock*	8/68	27	20	14	7
	4/69	24	18	12	7
	9/69	22	18	10	6
	2/70	11	17	10	8
Mulch*	8/68	26	26	17	21
	4/69	25	24	17	20
	9/69	26	26	16	17
	2/70	20	24	17	20
Plant Density*	8/68	5	3	2	1
	4/69	3	3	2	1
	9/69	5	1	2	2
	2/70	6	3	3	1
Ground Cover Index**	8/68	35	33	25	27
	4/69	32	30	23	26
	9/69	34	32	24	25
	2/70	28	30	24	27

* Bare soil, rock, mulch, and plant density index total 100.

** Ground cover index is computed as 100 minus number of hits on bare soil and rock not under a shrub overstory.

Table 3.--Badger Wash utilization

February 1970

	Percent use		Frequency	
	Upper Hanks (1A)	Oilwell (3A)	Upper Hanks (1A)	Oilwell (3A)
Grass				
Elymus Salinus	93	32	33	17
Hilaria jamesii	17	2	79	54
Oryzopsis hymenoides	8	12	46	37
Poa secunda	80	--	4	--
Sporobolus cryptandrus	8	--	17	--
Forb				
Aster arenosus	36	--	25	--
Aster venustus	--	37	--	50
Astragalus asclep.	--	0	--	12.5
Astragalus missouriensis	0	--	8	--
Bahia nudicaulis	7	--	25	--
Erigeron pumilus	84	8	33	21
Eriogonum bicolor	--	47	--	8
Phlox lougifolia	--	20	--	4
Sphaeralcea coccinea	64	27	12.5	33
Shrub				
Artemisia spinescens	36	40	25	4
Artemisia tridentata	27	10	46	8
Atriplex confertifolia	3	1	100	71
Atriplex corrugata	5	0	4	8
Atriplex nuttallii	--	1	--	58
Chrysothamnus greenii	47	20	50	71
Chrysothamnus nauseosus	--	0	--	4
Ephedra torreyana	20	40	4	4
Eurotia lanata	46	--	4	--
Gutierrezia sarothrae	2	3	67	50
Opuntia	0	0	29	4
Tetradymia spinosa	0	0	12.5	50

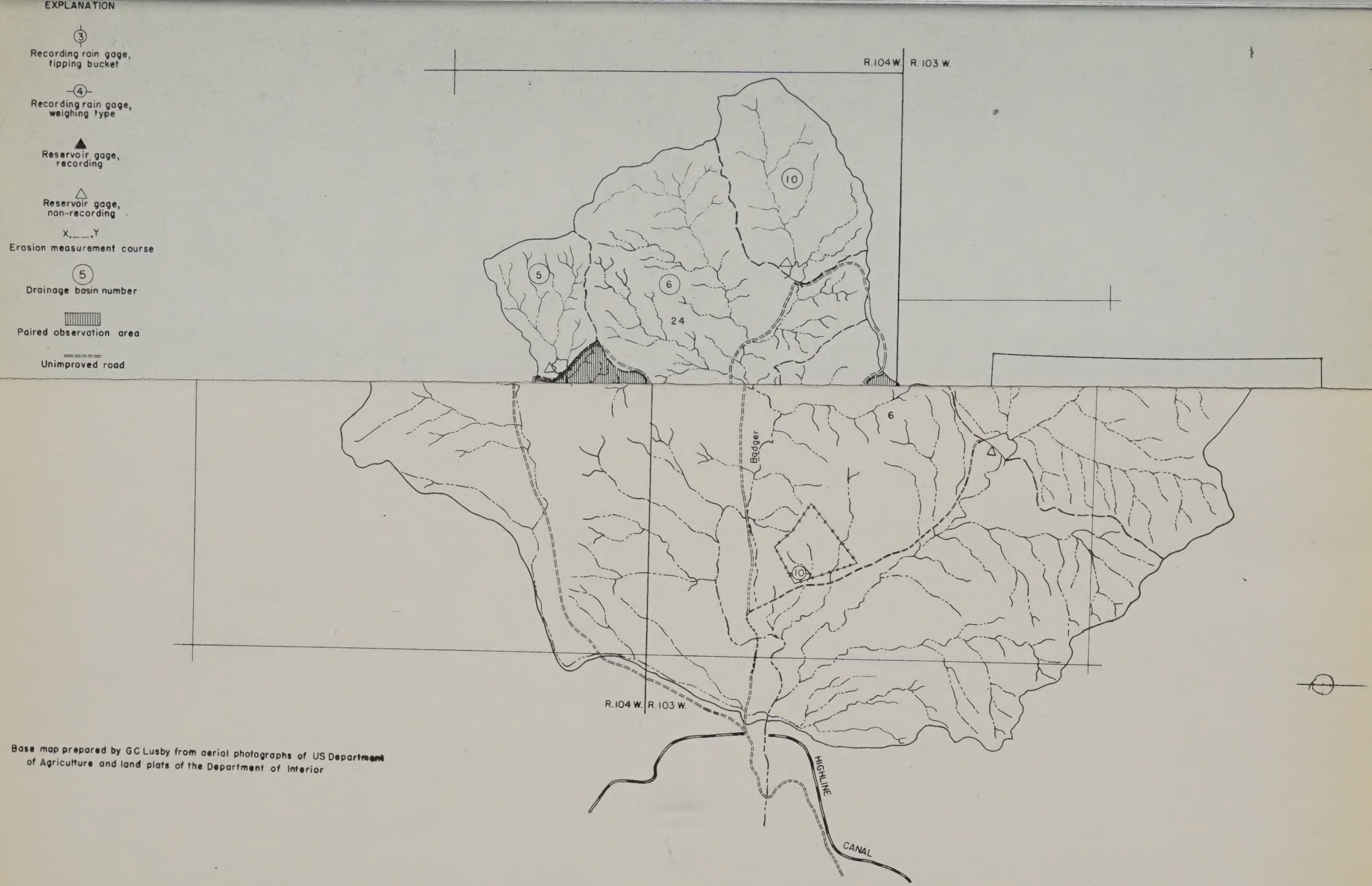
Table 4.--Average utilization of major grasses and shrubs during two periods of study.

	Upper Hanks		Oilwell	
	1954-1966*	1968-1970**	1954-1966*	1968-1970**
Grasses				
Elymus salina	79	85	83	50
Hilaria jamesii	38	7	37	20
Oryzopsis hymenoides	46	11	50	27
Sitanion hystrix	9	8	14	11
Shrubs				
Artemisia tridentata	39	32	36	38
Atriplex confertifolia	10	2	10	6
Atriplex nuttallii	--	--	25	16
Atriplex corrugata	--	--	7	19
Chrysothamnus greenii	38	36	37	33
Gutierrizia sarothrae	16	2	15	2

* Winter-spring use by cattle and sheep.
** Winter use by sheep only.

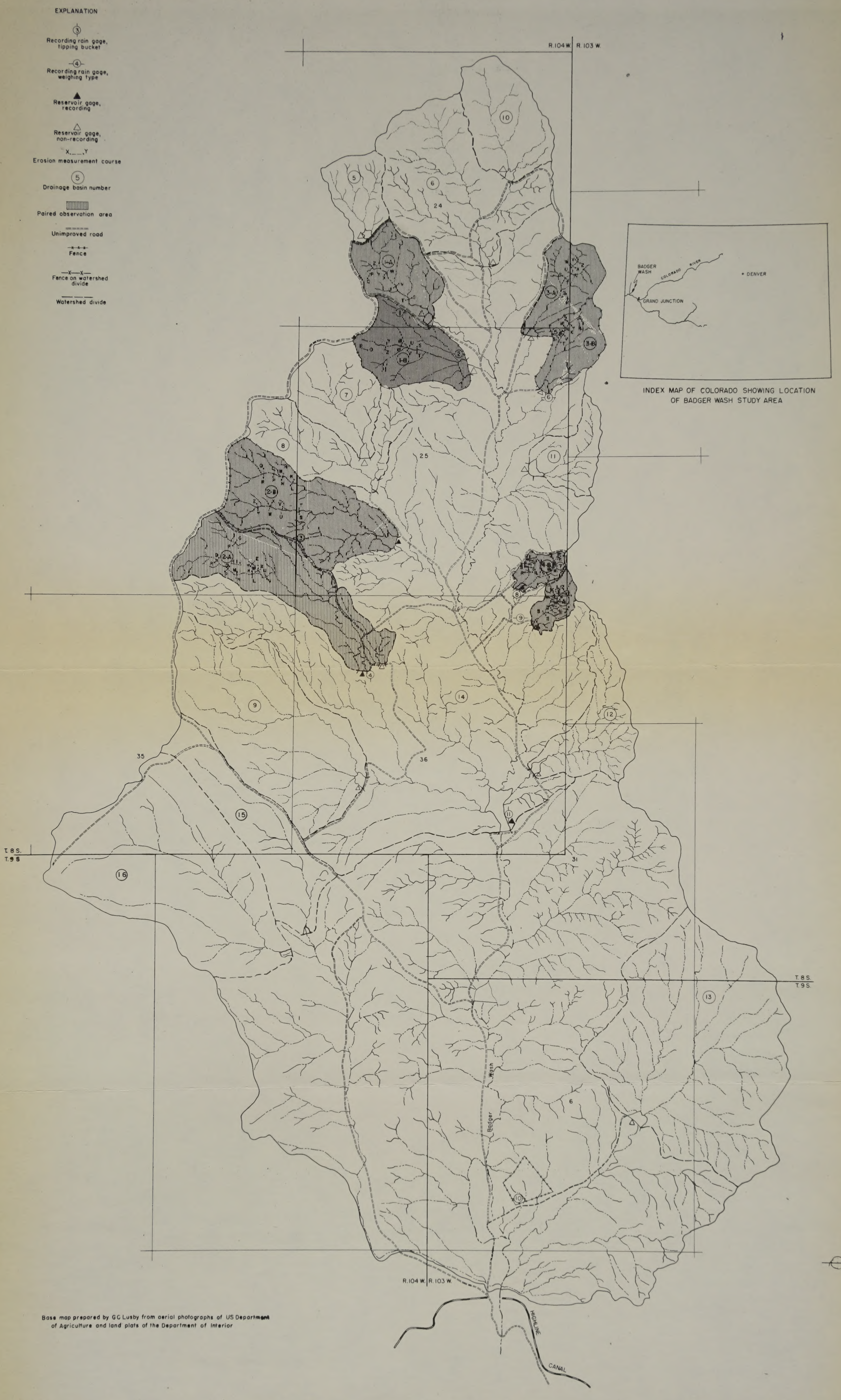
Table 5.--Soil-water relationships, Badger Wash

	Horizon	Shadscale-Galleta Grass		Nuttall Saltbush	
		Fall 1968	Spring 1969	Fall 1968	Spring 1969
Soil moisture content (percent)	1-3 2-2 2-3 3-1	2.9 4.5 4.9 4.9	13.0 13.9 11.7 9.2	3.9 6.3 6.7 6.8	13.6 14.6 12.3 9.8
Soil moisture stress (bars)	1-3 2-2 2-3 3-1	149.6 65.3 49.7 58.6	0.09 0.07 0.10 1.50	410.2 111.2 73.3 59.9	0.23 0.18 0.50 5.5
Depth to base of horizon (inches)	1-3 2-2 2-3 3-1		4.0 15.7 27.5 32.1		4.0 16.1 29.1 33.5
Moisture content at saturation (percent)	1-3 2-2 2-3 3-1		30.6 35.0 36.3 34.8		38.1 41.1 40.9 40.6
Average profile bulk density (gm/cm^3)			1.522		1.582


EXPLANATION
3
Recording rain gage, tipping bucket
4
Recording rain gage, weighing type
Reservoir gage, recording
Reservoir gage, non-recording
X___Y
Erosion measurement course
5
Drainage basin number
Paired observation area
Unimproved road
R.104 W.
R.103 W.
10
5
6
24
6
Badger
10
R.104 W.
R.103 W.
HIGHLINE
CANAL

Base map prepared by G C Lusby from aerial photographs of US Department of Agriculture and land plats of the Department of Interior

MAP OF BADGER WASH COOPERATIVE STUDY AREA, COLORADO, SHOWING HYDROLOGIC NETWORK


EXPLANATION
③ Recording rain gage, tipping bucket
-④- Recording rain gage, weighing type
▲ Reservoir gage, recording
△ Reservoir gage, non-recording
X.___.Y Erosion measurement course
⑤ Drainage basin number
▥ Paired observation area
Unimproved road
Fence
Fence on watershed divide
Watershed divide
R.104 W. R.103 W.
T.8 S. T.9 S.
24
25
35
36
31
6
Badger Wash
HIGHLINE CANAL
INDEX MAP OF COLORADO SHOWING LOCATION OF BADGER WASH STUDY AREA
BADGER WASH
COLORADO RIVER
DENVER
GRAND JUNCTION

Base map prepared by G.C. Lusby from aerial photographs of US Department of Agriculture and land plats of the Department of Interior

MAP OF BADGER WASH COOPERATIVE STUDY AREA, COLORADO, SHOWING HYDROLOGIC NETWORK

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